(i) The values of all the correlation and regression coefficients between any pair of relations, *i. e.*, heredity between any grade of individual kinship. The chief of these are actually calculated in the paper.

(ii) The value of the stability that results from any long or short process of selective breeding, and the variability of the breed so established. A coefficient of stability is introduced in the paper and discussed at some length. The consideration of the more rapid influence of in- and in-breeding is postponed.

(iii) The law of cross heredity, *i. e.*, the degree of relationship between two *different* organs in kindred. It is shown that the coefficient of cross heredity for any pair of organs in any grade of kindred is equal to the product of the coefficient of direct heredity in that grade into the coefficient of organic correlation.

(iv) That simple panmixia without active reversal of natural selection does not lead to degeneration.

It may be of interest to add that since the law of ancestral heredity allows for the variability of each individual ancestor from the ancestral type, giving that variability its share in the heritage of the offspring, it is inconsistent with Weismann's theory of the germplasma. It does not, of course, answer one way or the other the question as to the inheritance of acquired characters.

To sum up, then, it seems to the present writer that Galton's law of ancestral heredity leads to, what has not hitherto existed, a rounded and comprehensive theory of heredity. It describes with surprising closeness all facts so far quantitatively determined, and opens up a wide range of conclusions which await testing by fresh data. Should those data be in agreement with its predictions, then the law of ancestral heredity will in the future play as large a part in the theory of evolution as the law of gravitation has played in planetary theory. It is the quantitative basis on which Darwinism, the evolution of species by natural selection *combined with heredity*, will then be placed; and at one stroke it will clear away a veritable jungle of semi-metaphysical speculations and hypotheses, and this for the simple reason that it is based upon quantitative observations and not on verbal subtleties. It will be difficult, perhaps, to make people realize that there is a science of heredity, simple and consistent, in existence; yet even at the present time it is the number of observers and experimenters, rather than the science, which needs to be strengthened.

THE ROYAL SOCIETY'S ANTARCTIC CONFERENCE.

THE Royal Society held an important meeting on February 24th for the purpose of discussing Antarctic exploration, which is at present engaging the attention of the British government. We take from the London *Times* the following account of the discussion:

Dr. John Murray, of the Challenger Expedition, said that, from a scientific point of view, the advantages to be derived from a well-equipped and well-directed expedition to the Antarctic region would, at the present time, be manifold. Every department of natural knowledge would be enriched by systematic observations as to the order in which phenomena coexist and follow each other in regions of the earth's surface about which we knew very little or were wholly ignorant. It was one of the great objects of science to collect observations of the kind indicated, and it might be safely said that without them we could never arrive at a right understanding of the phenomena by which we were surrounded, even in the habitable parts of the globe. Dr. Murray pointed out a fundamental topographical difference between the Arctic and Antarctic. In the northern

hemisphere there was a polar sea almost completely surrounded by continental land, and continental conditions for the most part prevailed. In the southern hemisphere, on the other hand, there was almost certainly a continent at the South Pole which was completely surrounded by the ocean, and, in those latitudes, the most simple and extended oceanic conditions on the surface of the globe were encountered.

With reference to the atmosphere, Dr. Murray said that one of the most remarkable features in the meteorology of the globe was the low atmospheric pressure at all seasons in the southern hemisphere south of latitude 45° S., with the accompanying strong westerly and northwesterly winds, large rain and snow fall, all round the South Polar regions. There were, he believed, many indications that the extreme South Polar area was occupied by a vast anti-cyclone, out of which winds blew towards the girdle of low pressure outside the ice-bound region. The anti-cyclonic area at the South Pole appeared to be permanent, and, when in winter the sea-ice was for the most part continuous, and extended far to the north, the anti-cyclonic area had most probably a much wider extension than in summer. All observations in high southern latitudes indicated an extremely low summer temperature. In winter we had no direct observations. It was most likely that the prevailing winds blew out from the Pole all the year round towards the surrounding sea, as in the case of Greenland; but, unlike Greenland, this area was probably seldom traversed by cyclonic disturbances. But what had been stated only showed how little real knowledge we possessed concerning the atmospheric conditions of high southern latitudes. It was certain, however, that even two years' systematic observations within these regions would be of the utmost value for the future of meteorological science.

Dr. Murray next dealt with the Antarctic ice. From many points of view it would be important to learn something about the condition and distribution of Antarctic sea-ice during the winter months, and especially about the position of the huge table-shaped icebergs at this and other seasons of the year. These flat-topped icebergs, with a thickness of 1,200 ft. or 1,500 ft., with their stratification and their perpendicular cliffs, rising 150 ft. or 200 ft. above and sinking 1,100 ft. or 1,400 ft. below the level of the sea, formed the most striking peculiarity of the Antarctic Ocean. Their form and structure seemed clearly to indicate that they were formed on an extended land surface and had been pushed out over low-lying coasts into the sea. Ross sailed for 300 miles along the face of a great ice-barrier from 150 ft. to 200 ft. in height, off which he obtained depths of 1,800 ft. and 2,400 ft. All Antarctic land was not, however, surrounded by such inaccessible cliffs of ice. Kristensen and Borchgrevink landed on a pebbly beach, occupied by a penguin rookery, at Cape Adare without encountering any land-ice descending to the sea. Where a penguin rookery was situated we might be quite sure that there was occasionally open water for a considerable portion of the year, and that consequently landing might be effected without much difficulty or delay; and, further, that a party, once landed, might with safety winter at such a spot, where the penguins would furnish an abundant supply of food and fuel. A properly equipped party of observers situated at a point like this on the Antarctic continent for one or two winters might carry out a most valuable series of scientific observations, make successful excursions toward the interior, and bring back valuable information as to the probable thickness of the ice-cap, its temperature at different levels, its rate of accumulation, and its motions, concerning all of

which points there was much difference of opinion among scientific men. Was there an Antarctic continent? Dr. Murray pointed out that the lithological specimens which had been collected from the floor of the Antarctic Ocean, dropped there from icebergs—gneisses, granites, mica-schists, quartziferous diorites, grained quartzites, sandstones, limestones and shales—were distinctively indicative of continental land, and there could be no doubt about their having been transported from land situated towards the South Pole. From these and from specimens, including fossils, from off the land itself, we were thus in possession of abundant indications that there was a wide extent of continental land within the ice-bound regions of the southern hemisphere. The fossil remains indicated in these areas a much warmer climate in past times. It was not likely that any living land fauna would be discovered on the Antarctic continent away from the penguin rookeries. Still, an Antarctic expedition would certainly throw much light on many geological problems.

Dr. Murray went on to speak of magnetic and pendulum observations, geodetic measurements, tides and currents. In any Antarctic expedition, he said, magnetic observations would, of course, form an essential part of the work to be undertaken, and the importance of such observations had been frequently dwelt upon by eminent physicists and navigators. It might be possible to measure a degree on the Antarctic continent or ice-cap, which would be a most useful thing to do. By watching the motions of the icebergs and ice from land at Cape Adare much would be learnt about oceanic currents, and our knowledge of the tides would be increased by a systematic series of tidal observations on the shores of the Antarctic continent, where we had at present no observations. The series of scientific observations here indicated would fill up many other gaps in our knowledge of the physical conditions of these high southern latitudes.

With regard to the depth of the Antarctic Ocean, the few indications which we possessed seemed to show that there was a gradual shoaling of the ocean from very deep water towards the Antarctic continent, and so far as we yet knew, from either soundings or temperature observations, there were no basins cut off from general oceanic circulation by barriers or ridges, similar to those found in the Arctic. Further samples in addition to those already obtained from different depths in the unexplored regions would yield most interesting information. As to the mean daily temperature of the surface waters of the Antarctic, all observations seemed to show that the surface water was warmer than the air during the summer months. After referring to the Challenger observations on surface and deep-sea temperatures, and to the relations between the Antarctic waters and those of the oceanic waters to the north, Dr. Murray stated that a fuller examination of these waters was most desirable at different seasons of the year, with improved thermometers and sounding machines. Dr. Murray referred in some detail to the pelagic and shallow-water life found in the Antarctic and Sub-Antarctic Ocean, and to the interesting scientific problems connected therewith. He dwelt especially on the many forms which have been found common to both the North and the South Polar Oceans, hinting at a problem of great interest which he discussed in the last volume of the 'Challenger' publications in connection with the former distribution of life in the ocean.

What was urgently required, he said, with reference to the biological problems indicated was a fuller knowledge of the facts, and it could not be doubted that an Antarctic expedition would bring back col-

lections and observations of the greatest interest to all naturalists and physiologists; and without such information it was impossible to discuss with success the present distribution of organisms over the surface of the globe, or to form a true conception of the antecedent conditions by which that distribution had been brought about. There were many directions, Dr. Murray concluded, in which an Antarctic expedition would carry out important observations besides those to which he had alluded. From the purely exploratory point of view much might be urged in favor of an Antarctic expedition at an early date. For the further progress of scientific geography it was essential to have a more exact knowledge of the topography of the Antarctic regions. This would enable a more just conception of the volume relations of land and sea to be formed, and in connection with pendulum observations some hints as to the density of the sub-oceanic crust might be obtained. In case what he had said might possibly have created the impression that we really knew a great deal about the Antarctic regions, it was necessary to re-state that all the general conclusions which he had indicated were largely hypothetical, and he again urged the necessity for a wider and more solid base for generalizations. The results of a successful Antarctic expedition would mark a great advance in the philosophy —apart from the mere facts—of terrestrial science. "No thinking person doubts," Dr. Murray concluded, "that the Antarctic will be explored. The only questions are—when, and by whom? I should like to see the work undertaken at once, and by the British navy. I should like to see a sum of £150,000 inserted in the estimates for the purpose. The government may have sufficient grounds for declining to send forth such an expedition at the present time, but that is no reason why the scientific men of the country should not urge that the exploration of the Antarctic would lead to important additions to knowledge, and that, in the interests of science among English-speaking people the United Kingdom should take not only a large but a leading part in any such exploration."

The Duke of Argyll, who was not present, but had sent a note on the subject, referred to the generally accepted glacial-period theory, with which he disagreed, and pointed out that the Antarctic continent was unquestionably the region of the earth in which glacial conditions were at the *maximum*, and therefore it was the region in which we must look for all the information attainable towards, perhaps, the most difficult problem with which geological science had to deal.

Sir Joseph D. Hooker (who was a member of Sir James Ross's expedition half-a-century ago) said that Dr. Murray's admirable summary of the scientific information obtainable by an organized exploration of the Antarctic regions left nothing further to be said under that head. He could only record the satisfaction with which he heard it read, and his earnest hope that it would lead to action being taken by the government in the direction indicated. Sir Joseph Hooker referred to the vast area of the unknown region which was to be the field for investigation—a region which in its full extension reached from the latitude of 60 S. to the Southern Pole, and embraced every degree of longitude. Referring to the vast ice-fields which covered the Antarctic area, Sir Joseph said that the explorer naturally asked where and how the components of these great fields of ice had their origin, how they arrived at or maintained their present position, what were their rate of progress and courses, and what was their influence on the surrounding atmosphere and ocean. That they orginated over extensive areas of open water in a higher latitude than

they now occupied, that they were formed of frozen ocean water and snowflakes, and that winds and currents had brought them to where we now found them was certain. But of the position of the Southern, open waters, with the exception of the comparatively diminutive sea east of Victoria Land, we knew nothing, nor did we know anything of the relative amount of snow and ice of which they were composed, or of their age, or of the winds and currents, that had carried them to a lower latitude. The other great glacial feature of the Antarctic area was 'the ice Barrier' which Ross traversed for 300 miles in the 78th and 79th degrees of south latitude, maintaining throughout the character of an inaccessible precipitous ice-cliff (the sea front of a gigantic glacier) of 150 ft. to 200 ft. in height. This stupendous glacier was, no doubt, one parent of the huge table-topped ice-island that infested the higher latitudes of the southern ocean; but, as in the case of the pack-ice, we did not know where the barrier had its origin, or anything further about it than that it rested in great part upon a comparatively shallow ocean-bottom. It probably abutted upon land, possibly upon an Antarctic continent. He did not see any other method of settling this important point, except by the use of a captive balloon —an implement with which he hoped any future Antarctic expedition might be supplied. He chose the subject of the Antarctic pack-ice as his theme not only because it was one of the very first of the phenomena that demanded the study of the explorer, but because it was the dominant feature in Antarctic navigation. The Antarctic fauna and flora were most important, for the South Polar Ocean swarmed with animal and vegetable life. So prolific was the Antarctic Ocean that the naturalist need never be idle, no, not even for one of the twenty-four hours of daylight throughout the Antarctic summer; and he looked to the results of a comparison of the oceanic life of the Arctic and Antarctic regions as the heralding of an epoch in the history of biology.

Dr. Nansen said that Great Britain was undoubtedly the country to undertake a great Antarctic expedition, for which the whole scientific world was now waiting impatiently. He confined his remarks to the portance of a land expedition. He was not at all sure whether the Antarctic land was a continent, and not a great group of islands. At all events there must be one or several ice-caps, and the exploration of these would yield scientific information of the greatest value. Geologists were looking to the Antarctic for full light to be thrown on the glacial epoch. It might be difficult to get on the Antarctic inland ice, but not at all impossible. The surface was probably smoother than in Greenland. Observations on the thickness of the ice would yield valuable results. On the other matters referred to by Dr. Murray he was confident that a properly equipped Antarctic expedition would yield excellent results. He pointed out the important influence in meteorology which this enormous ice-sheet must have on the climatology of the whole world. If Great Britain sent out such an expedition, he was sure that Norway would be willing to send out an expedition for co-operation upon the land. We know the conditions of polar exploration now so much better that we could much more readily lay our plans for investigating a region which had such a vast influence on the ocean which England was proud to rule.

Dr. Neumayer, Director of the Hamburg Observatory, said he considered it his duty to attend that meeting in order to show the value he placed on British Antarctic research in the past. He spoke of the urgent need which the science of terrestrial magnetism had of continuous observations in the Antarctic area, if possible simulta-

neously at several stations, by expeditions of various nationalities. He strongly advocated international cooperation, and this suggestion was warmly supported by the meeting. Antarctic exploration must be advocated, and strongly, on purely scientific grounds. Practical results to humanity would follow, as they always had followed scientific research in the past. Terrestrial magnetism was positively at a standstill for lack of *data* from the Antarctic. Dr. Neumayer pointed out, from the few observations made, the intensity of magnetism on the Australian side of the Antarctic compared with what had been found on the opposite side, and the curious coincidence of this with intensity of auroral phenomena. He spoke of Gauss's famous mathematical theory of magnetism, which had stood the test till now; but we were absolutely unable to form a physical theory until we obtained the necessary *data* from Antarctica.

Sir Clements Markham, President of the Royal Geographical Society, fully concurred with every word spoken by Dr. Murray on the subject of the scientific results, and more especially of the geographical results of an Antarctic expedition. It was quite sufficient to point out the vast extent of the unknown area; and that no area of like extent on the surface of the earth ever failed to yield results of practical, as well as of purely scientific, value by its exploration. But there was much more to be said in the present instance, because the little that we did know of the Antarctic regions pointed unmistakably to the very great importance and interest that was certain to attend further research. More complete examination was necessary before any approach to accuracy could be obtained respecting the nature and extent of the supposed ice-cap. We knew that the southern continent was a region of actual volcanic activity; but the extent, nature and effect of this activity remained to be ascertained. On the Antarctic circle, land had been sighted at numerous points, but it was unknown whether what had been seen indicated small islands or a continuous coast-line. The extent of the ice-wall and the relations between that and the ice-cap were unknown; as well as the distribution of land and sea, and of ice and water in the summer, and the causes which influenced such distribution. The investigation of each one of these points, and of many others, would lead to further discoveries of the deepest interest to geographical science.

Dr. Alexander Buchan, Secretary of the Scottish Meteorological Society, emphasized the absolute necessity of further meteorological research in the Antarctic before we could form any satisfactory scheme of the climate of the globe.

Sir Archibald Geikie, Director-General of the Geological Survey, said that hardly anything was yet known of the geology of the Antarctic regions. By far the most important contributions to our knowledge of the subject were made by the expedition under Sir James Ross. But as he was unable to winter with his ships in the higher latitudes, and could only here and there with difficulty effect a landing on the coast, most of the geological information brought home by him was gathered at a greater or less distance from the land with the aid of the telescope. We did not know whether the land was a continent or a group of islands. There were indications of Paleozoic rocks, which emphasized the necessity for further research. Among the specimens brought home from Seymour Island in the same district were a few containing some half dozen species of fossil shells, which were believed to point to the existence of Lower Tertiary rocks, one of the organisms resembling a form found in the old Tertiary formations of Patagonia. Large well-developed shells of Cucullæ

and Cytherea undoubtedly indicated the former existence of a far milder climate in these Antarctic seas than now prevailed. If a chance landing for a few hours on a bare islet could give us these interesting glimpses into the geological past of the South Polar regions, what would not be gained by a more leisurely and well-planned expedition? But perhaps the geological domain that would be most sure to gain largely from such exploration would be that which embraced the wide and fascinating field of volcanic action. In the splendid harvest of results brought home by Sir James Ross one of the most thrilling features was the discovery of a volcano rising amid the universal snows to a height of more than 12,000ft., and actively discharging 'flame and smoke,' while other lofty cones near it indicated that they, too, had once been in vigorous eruption. Ross landed on one or two islands near that coast, and brought away some pieces of volcanic rocks. There was other evidence of past and present volcanic action on the Antarctic land. This region was probably one of the most interesting volcanic tracts on the face of the globe. Yet we could hardly be said to know more of it than its mere existence. The deeply interesting problems which it suggested could not be worked out by transitory voyagers. They must be attacked by observers stationed on the spot. Ross thought that a winter station might be established near the foot of Mount Erebus, and that the interior could easily be traversed from there to the magnetic pole. Another geological field where much fresh and important information might be obtained by Antarctic exploration was that of ice and ice-action. Our northern hemisphere was once enveloped in snow and ice, and though for more than half a century geologists had been studying the traces of the operations of this ice-covering they were still far from having cleared up all the difficulties of the study. The Antarctic ice-cap was the largest in the world. Its behavior could probably be watched along many parts of its margin, and this research would doubtless afford great help in the interpretation of the glaciation of the northern hemisphere. To sum up, geologists would hail the organization and dispatch of an Antarctic expedition, in the confident assurance that it could not fail greatly to advance the interests of their science.

Mr. P. L. Sclater, Secretary of the Zoological Society, considered it highly desirable to ascertain more exactly what forms of animal life were to be found on the Antarctic continent and in the adjacent seas. So far animal life in Antarctica has been found to be rather poorly represented. Most of the Antarctic specimens of these animals in our national collection had been obtained during the voyage of the Erebus and Terror, and were now antiquated. In his opinion the special point of interest in the zoology of Antarctica would be the further investigation of its extinct fauna. As in the North Polar region, so in the South Polar continent, it was already positively certain that animals of a character that could not under present conditions possibly exist there were formerly present. Further investigations into this subject would be likely to lead to most important results as regarded the climate of the Polar extremities of the earth in former ages, and would perhaps give us some ideas as to the date at which the ice-caps that now covered them originated. It was therefore of primary importance that in future Antarctic exploration great attention should be paid to the extinct fauna of the South Polar lands.

Professor D'Arcy Thompson (of the Behring Sea Commission) insisted upon the abundance of sea-life at least in the Antarctic, although we had only eight Antarctic dredgings. He believed there was an intimate connection between the Antarctic

and North Pacific, though not with the Atlantic. Admiral Sir William Wharton, Hydrographer to the Admiralty, said that an Antarctic expedition must be under naval discipline. He hoped such an expedition would not be far off, and he felt sure there would be rush of officers and men to join it. Sir John Evans, in summing up, said the discussion had maintained a high level. All were agreed as to the immense advantages of an expedition, and he was sure it would find a warm advocate in the Hydrographer.

ELLIS'S NORTH AMERICAN FUNGI.

Twenty years ago Mr. J. B. Ellis, of Newfield, N. J., began the distribution of a most important series of volumes containing authentic specimens of the fungi of North America. Many botanists have availed themselves of the opportunity here afforded of securing excellent specimens of all groups of the fungi. For eight years Mr. Ellis worked alone, at the end of which he had issued fifteen volumes ('centuries'), each containing one hundred specimens. He was then joined by Mr. B. M. Everhart, and from this time the series bore the names of both authors. The announcement is now made that this work has been brought to a close.

The importance of being able to fix accurately the date of publication of each of the centuries is so great that the following statement by Mr. Ellis is given for the benefit of the readers of Science: Century I., September 6, 1878; II., April 15, 1879; III., February 11, 1880; IV., April 20, 1880; V., January 28, 1881; VI. and VII., May 23, 1881; VIII. and IX., April 13, 1882; X. and XI., April 26, 1883; XII. and XIII., April 15, 1884; XIV. and XV., March 25, 1885; XVI. and XVII., March 16, 1886; XVIII. and XIX., March 13, 1887; XX. and XXI., March 23, 1888; XXII. and XXIII., March 6, 1889; XXIV. and XXV., February 19, 1890; XXVI. and XXVII., February 21, 1891; XXVIII., April 30, 1892; XXIX., March 2, 1893; XXX., October 21, 1893; XXXI., April 18, 1894; XXXII., November 26, 1894; XXXIII., March 25, 1895; XXXIV., February 3, 1896; XXXV., December 16, 1896; XXXVI., February 1, 1898.

In regard to the foregoing Mr. Ellis says: "The dates on this sheet are the dates on which the centuries were sent to Charles E. Bessey. Usually when a century (or oftener two centuries) was ready only three or four were sent each day, so that some subscribers received their copies at a later date than others—from one to three weeks in some cases."

As to the number of copies of each century issued Mr. Ellis says: "I am not sure just how many copies of Century I. were issued, but I think there were thirty-five. The number was afterwards increased to forty, and then to fifty, and from Century XVII., to sixty." There were thus about two hundred thousand specimens in this great work. What wonder that the author upon whom the greater part of the labor has fallen should wish rest.

This notice would be incomplete without a reference to the part taken by Mrs. Ellis in the preparation of the volumes. The writer recalls a pleasant letter from Mr. Ellis shortly after the distribution began, in which he spoke of the fact that Mrs. Ellis now bound the books, and that they were better and neater than those of Century I., which came from a professional binder. From that time her hands made all the books (about two thousand), folded most of the papers for the specimens, and pasted the packets into the books.

While the distribution known as the 'North American Fungi' now comes to an end, the authors will continue for a time their second edition under the name of 'Fungi Columbiani.' This was begun in